IN THE CLAIMS:

1. (Currently Amended) A frequency synchronization apparatus that estimates a frequency error between an input signal from an external source and a reference signal, based on a correlation therebetween, and corrects the input signal so as to cancel out the frequency error, the input signal including a synchronization symbol that is composed of a synchronization waveform that exhibits a predetermined autocorrelation property and is included at least twice in the synchronization symbol, and the reference signal expressing a waveform that is identical to the synchronization waveform, the frequency synchronization apparatus comprising:

a correlation unit successively finding correlation vectors between the input signal and the reference signal;

a timing detection unit generating, based on chronological transition in magnitude of the obtained correlation vectors, a synchronization waveform timing signal that indicates a predetermined timing in each cycle of the synchronization waveform;

a first frequency error detection unit finding a frequency error between the input signal and the reference signal, based on an average phase difference between each pair of chronologically neighboring correlation vectors, according to the predetermined timing indicated by the synchronization waveform timing signal;

an absolute phase error detection unit finding an absolute phase error between the input signal and the reference signal, based on chronological transition of absolute phase of correlation vectors found with the timing indicated by the synchronization waveform timing signal; [[and]]

a first frequency correction unit correcting the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the found frequency error and the found absolute phase error;

a second frequency correction unit being supplied with a control signal, and giving an output signal from the first frequency correction unit a frequency shift corresponding to the control signal;

a phase error detection unit demodulating an output signal from the second frequency correction unit and successively finding symbol points in the demodulated output signal, and detecting a phase error between the found symbol points and symbol points able to be found in a modulation method of the output signal; and

a second frequency error detection unit successively outputting to the second frequency correction unit a control signal for giving an output signal from the first frequency correction unit a frequency shift that cancels out the detected phase error.

2. (Original) The frequency synchronization apparatus of Claim 1, further comprising:

a frequency error holding unit holding the found frequency error, and, when a new frequency error is subsequently found, updating the held frequency error with the new frequency error depending on a difference between the held frequency error and the new frequency error; and

an absolute phase error holding unit holding the found absolute phase error, and, when a new absolute phase error is subsequently found, updating the held absolute phase error

with the new absolute phase error depending on a difference between the held absolute phase error and the new absolute phase error,

wherein the first frequency correction unit corrects the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the frequency error being held by the frequency error holding unit and the absolute phase error being held by the absolute phase error holding unit.

3. (Cancelled)

4. (Currently Amended) The frequency synchronization apparatus of Claim [[3]] 1, further comprising:

a frequency error holding unit holding the found frequency error, and, when a new frequency error is subsequently found, updating the held frequency error with the new frequency error depending on a difference between the held frequency error and the new frequency error; and

an absolute phase error holding unit holding the found absolute phase error, and, when a new absolute phase error is subsequently found, updating the held absolute phase error with the new absolute phase error depending on a difference between the held absolute phase error and the new absolute phase error,

wherein the first frequency correction unit corrects the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the frequency error being held by the frequency error holding unit and the absolute phase error being held by the absolute phase error holding unit.

5. (Currently Amended) The frequency synchronization apparatus of Claim [[3]] 1,

wherein the input signal has been modulated according to a multicarrier modulation method,

the phase error detection unit demodulates an output signal from the second frequency correction unit and, for each sub-carrier in the demodulated output signal, successively finds symbol points in the sub-carrier and detects phase error between the found symbol points and symbol points able to be obtained in a modulation method of the sub-carrier,

the frequency synchronization apparatus further comprises:

a phase error averaging unit averaging phase errors detected simultaneously for all or some of the sub-carriers, and

the second frequency detection unit successively outputs to the second frequency correction unit a control signal for giving an output signal from the first frequency correction unit a frequency shift that cancels out the average phase error.

6. (Original) The frequency synchronization apparatus of Claim 1, wherein

the input signal includes a data symbol in addition to the synchronization symbol, and

a band of the synchronization symbol is limited so as to fall within an occupied frequency band of the data symbol.

7. (Original) The frequency synchronization apparatus of Claim 6, wherein

the synchronization symbol is characterized in that the synchronization waveform is included at least twice with a predetermined time interval therebetween.

8. (Currently Amended) A frequency synchronization circuit that estimates a frequency error between an input signal from an external source and a reference signal, based on a correlation therebetween, and corrects the input signal so as to cancel out the frequency error, the input signal including a synchronization symbol that is composed of a synchronization waveform that exhibits a predetermined autocorrelation property and is included at least twice in the synchronization symbol, and the reference signal expressing a waveform that is identical to the synchronization waveform, the frequency synchronization circuit comprising:

a correlation circuit successively finding correlation vectors between the input signal and the reference signal;

a timing detection circuit generating, based on chronological transition in magnitude of the obtained correlation vectors, a synchronization waveform timing signal that indicates a predetermined timing in each cycle of the synchronization waveform;

a first frequency error detection circuit finding a frequency error between the input signal and the reference signal, based on an average phase difference between each pair of chronologically neighboring correlation vectors, according to the predetermined timing indicated by the synchronization waveform timing signal;

an absolute phase error detection circuit finding an absolute phase error between the input signal and the reference signal, based on chronological transition of absolute phase of correlation vectors found with the timing indicated by the synchronization waveform timing signal; [[and]]

a first frequency correction circuit correcting the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the found frequency error and the found absolute phase error;

a second frequency correction unit being supplied with a control signal, and giving an output signal from the first frequency correction unit a frequency shift corresponding to the control signal;

a phase error detection unit demodulating an output signal from the second frequency unit and successively finding symbol points in the demodulated output signal, and detecting a phase error between the found symbol points and symbol points able to be found in a modulation method of the output signal; and

a second frequency error detection unit successively outputting to the second frequency correction unit a control signal for giving an output signal from the first frequency correction unit a frequency shift that cancels out the detected phase error.

9. (Currently Amended) A one-chip integrated circuit that estimates a frequency error between an input signal from an external source and a reference signal, based on a correlation therebetween, and corrects the input signal so as to cancel out the frequency error, the input signal including a synchronization symbol that is composed of a synchronization waveform that exhibits a predetermined autocorrelation property and is included at least twice in the synchronization symbol, and the reference signal expressing a waveform that is identical to the synchronization waveform, the one-chip integrated circuit comprising:

an input terminal obtaining the input signal;

a correlation circuit successively finding correlation vectors between the input signal and the reference signal;

a timing detection circuit generating, based on chronological transition in magnitude of the obtained correlation vectors, a synchronization waveform timing signal that indicates a predetermined timing in each cycle of the synchronization waveform;

a first frequency error detection circuit finding a frequency error between the input signal and the reference signal, based on an average phase difference between each pair of chronologically neighboring correlation vectors, according to the predetermined timing indicated by the synchronization waveform timing signal;

an absolute phase error detection circuit finding an absolute phase error between the input signal and the reference signal, based on chronological transition of absolute phase of correlation vectors found with the timing indicated by the synchronization waveform timing signal;

a first frequency correction circuit correcting the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the found frequency error and the found absolute phase error; [[and]]

a second frequency correction unit being supplied with a control signal, and giving an output signal from the first frequency correction unit a frequency shift corresponding to the control signal;

a phase error detection unit demodulating an output signal from the second frequency correction unit and successively finding symbol points in the demodulated output signal, and detecting a phase error between the found symbol points and symbol points able to be found in a modulation method of the output signal; and

an output terminal outputting the corrected input signal.

10. (Currently Amended) A frequency synchronization method that estimates a frequency error between an input signal from an external source and a reference signal, based on a correlation therebetween, and corrects the input signal so as to cancel out the frequency error, the input signal including a synchronization symbol that is composed of a synchronization waveform that exhibits a predetermined autocorrelation property and is included at least twice in the synchronization symbol, and the reference signal expressing a waveform that is identical to the synchronization waveform, the frequency synchronization method comprising:

a correlation step of successively finding correlation vectors between the input signal and the reference signal;

a timing detection step of identifying, based on chronological transition in magnitude of the obtained correlation vectors, each cycle of the synchronization waveform;

a first frequency error detection step of finding a frequency error between the input signal and the reference signal, based on an average phase difference between each pair of chronologically neighboring correlation vectors according to the identified cycles;

an absolute phase error detection step of finding an absolute phase error between the input signal and the reference signal, based on chronological transition of absolute phase of correlation vectors according to the identified cycles; [[and]]

a first frequency correction step of correcting the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the found frequency error and the found absolute phase error;

a second frequency correction step of being instructed of a frequency shift, and giving a signal obtained in the first frequency correction step the instructed frequency shift;

a phase error detection step of demodulating a signal obtained in the second frequency correction step and successively finding symbol points in the demodulated output signal, and detecting a phase error between the found symbol points and symbol points that are found in a modulation method of the output signal; and

a second frequency error detection step of successively instructing to the second frequency correction step of a frequency shift that cancels out the detected phase error.

11. (Original) The frequency synchronization method of Claim 10, further comprising:

a frequency error recording step of recording the found frequency error, and, when a new frequency error is subsequently found, updating the recorded frequency error with the new frequency error depending on a difference between the recorded frequency error and the new frequency error; and

an absolute phase error recording step of recording the found absolute phase error, and, when a new absolute phase error is subsequently found, updating the recorded absolute phase error with the new absolute phase error depending on a difference between the recorded absolute phase error and the new absolute phase error,

wherein the first frequency correction step corrects the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the frequency error recorded in the frequency error holding step and the absolute phase error recorded in the absolute phase error recording step.

12. (Cancelled)

13. (Currently Amended) The frequency synchronization method of Claim [[12]] 10, further comprising:

a frequency error recording step of recording the found frequency error, and, when a new frequency error is subsequently found, updating the recorded frequency error with the new frequency error depending on a difference between the recorded frequency error and the new frequency error; and

an absolute phase error recording step of recording the found absolute phase error, and, when a new absolute phase error is subsequently found, updating the recorded absolute phase error with the new absolute phase error depending on a difference between the recorded absolute phase error and the new absolute phase error,

wherein the first frequency correction step corrects the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the frequency error recorded in the frequency error holding step and the absolute phase error recorded in the absolute phase error recording step.

14. (Currently Amended) The frequency synchronization method of Claim [[12]] 10, wherein

the input signal has been modulated according to a multicarrier modulation method,

the phase error detection step demodulates a signal obtained in the second frequency correction step and, for each sub-carrier in the demodulated output signal,

successively finds symbol points in the sub-carrier and detects phase error between the found symbol points and symbol points able to be obtained in a modulation method of the sub-carrier,

the frequency synchronization method further comprises:

a phase error averaging step of averaging phase errors detected simultaneously for all or some of the sub-carriers in the absolute phase error detection step, and

the second frequency detection step successively instructs the second frequency correction step of a frequency shift that cancels out the average phase error.

15.-21. (Cancelled)

22. (Currently Amended) A frequency demodulation method that corrects an input signal from an external source, based on a correlation between the input signal and a reference signal, and demodulates the corrected input signal, the input signal including a synchronization symbol that is composed of a synchronization waveform that exhibits a predetermined autocorrelation property and is included at least twice in the synchronization symbol, and the reference signal expressing a waveform that is identical to the synchronization waveform, the frequency demodulation method comprising:

a frequency synchronization step of finding a frequency error between the input signal and the reference signal, based on an average phase difference between each pair of chronologically neighboring correlation vectors found cyclically between the input signal and the reference signal, finding an absolute phase error between the input signal and the reference signal, based on chronological transition of absolute phase of the correlation vectors, and correcting the input signal based on the found frequency error and the found absolute phase error; and

a demodulation step of demodulating the corrected input signal, thereby generating a demodulated signal,

wherein the frequency synchronization step further includes:

a correlation sub-step of successively finding correlation vectors between the input signal and the reference signal;

a timing detection sub-step of identifying, based on chronological transition in magnitude of the obtained correlation vectors, each cycle of the synchronization waveform;

a first frequency error detection sub-step of finding a frequency error between the input signal and the reference signal, based on an average phase difference between each pair of chronologically neighboring correlation vectors according to the identified cycles ;

an absolute phase error detection sub-step of finding an absolute phase error between the input signal and the reference signal, based on chronological transition of absolute phase of correlation vectors according to the identified cycles; [[and]]

a first frequency correction sub-step of correcting the input signal by simultaneously giving the input signal a frequency shift and a phase rotation that cancel out the found frequency error and the found absolute phase error;

a second frequency correction sub-step of being instructed of a frequency shift, and giving a signal obtained in the first frequency correction step the instructed frequency shift;

a phase error detection sub-step of demodulating a signal obtained in the second frequency correction step and successively finding symbol points in the demodulated output signal, and detecting a phase error between the found symbol points that are found in a modulation method of the output signal; and

a second frequency error detection sub-step of successively instructing to the second frequency correction step of a frequency shift that cancels out the detected phase error.

23. (Cancelled)